PATENT SPECIFICATION

643,863

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COMPLETE SPECIFICATION

Improvements in or relating to Linearly Extending Actuators

We, BENDIX AVIATION CORPORATION, a Corporation of the State of Delaware, United States of America, of 401, Bendix Drive, South Bend, Indiana, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to actuators having a linearly movable output element, and particularly to means for regulating the strokes of such reciprocable actuator elements.

An example of an actuator for which the invention is adapted and which is illustrated herein, is one for operating a member, such as a tab, a flap or other element of an airplane.

In connection with such application, it is important in certain cases, that the actuated member be positioned and stopped with precision in any position to which it may be moved, and also important, as improved by the invention hereof, that the limiting movements of the actuator be adjustable and precisely effected in a very short distance.

It is also important that such actuators should be as light in weight, and occupy as little space as possible consistent with effective operation and other factors.

According, therefore, to the present invention there is provided an actuator device comprising a linearly movable output element adapted to be driven by a motor or the like and having means carried thereby for actuating switch or other responsive means during movement of the element to limit its stroke, the actuating means including a member surrounding the element and having an outer peripheral portion eccentric to the axis of movement thereof, wherein the said member is angularly adjustable about the axis of said element for varying the movement of said element necessary to actuate the responsive means, and wherein the member is held in its adjusted position by holding means associated therewith.

The invention will now be described by way of example with reference to the accompanying drawings in which:—

Figure 1 is a view, on an enlarged scale, partially in side elevation and partially in section of an actuator of one form embodying the invention;

Figure 2 is a view, taken substantially along the line 2—2 of Figure 1 showing a member thereof in different positions indicated by full and broken lines, respectively;

Figure 3 is a view similar to a portion of Figure 1 showing a modification of the invention.

Referring to Figure 1. the device shown comprises, in general, a gear housing 10 having portions 12 and 14 for enclosing a gear train 16, a housing portion 18 enclosing limit switches 20 and 22 and portions of means 24, for attachment to a member to be actuated, a housing portion 26 enclosing a driving disc 28, and clutch disc and brake means 30 and 32, respectively, a housing portion 34 enclosing electromagnetic means 36, and a housing portion 38 comprising parts 40 and 42 enclosing a reversible motor 44. The housing portions 12, 14, 18, 26, 34, 40 and 42 are connected to each other as by screws, dowel pins and the like.

The device, as a whole, is adapted to be mounted on a base, as by bolts 48 and 50 extending through the housing portions 14 and 18, respectively, and connected to an element to be actuated, as by an eye 52 on the means 24.

The means 24 comprises a shaft 54 having a short length 56 journalled, as by ball bearings 58 and 60 in the gear housing portion 14, and a long screw length 62 protruding from the gear housing 10.

The gear train 16 includes an output gear 64 on the short length 56 of the shaft 54, and an input gear or pinion 66 fixed

to a short driven shaft 68, which is journaled in ball bearings 70 in the housing 26.

The clutch disc 30 is splined to the driven shaft 68 for rotation therewith and axial movement relative thereto, and is biased to the right, as shown, toward a lock ring 72 in a groove of the shaft 68, by a spring 74 around the shaft 68 pressing oppositely with a given force between the clutch disc and the inner race of one of the ball bearings 70.

The perimeter of the brake 32 is of substantially L-section one portion 75 of which, having the braking surface, is of larger inside diameter than the outer diameter of the driving disc 28 and normally, in the inactive positions of the parts illustrated, surrounds the disc 28 in engagement with the clutch disc 30 under pressure of springs 76 having greater force than the force of the clutch spring 74. The springs 76, of which in this instance there are four, are spaced about the disc axis, and mounted around pins 78 which are screw threaded or pressed in place in the brake 32.

The driving disc 28 is keyed to an armature shaft 82 of the motor 44, and fixed to the shaft, as by a nut 84. The shaft 82 is journaled in an anti-friction bearing 86, which is mounted in a partition 88 having a perimetral portion 90 clamped between the housing portions 14 and 34.

The electromagnetic means 36 comprises a pair of laminated cores 92 substantially E-shape in section, only one of which shows, and which are in register with each other at opposite sides of the driving or motor shaft 82. A coil winding 94 links the middle legs of the cores 92 around the shaft 82 spaced from the latter, which coil 94 is connected to the motor 44 for simultaneous energization and deenergization therewith.

Laminated armatures 96, disposed opposite the pole ends of the core legs, are carried by a diamagnetic plate 98. The plate is mounted on pins 100 which are disposed in tubular spacers 101 and with the latter are slidably extended through the partition 88 and fixed to the brake 32.

Movement of the armatures 96, to the left as viewed in Figure 1, is effected by the springs 76 and limited by engagement of the plate 98 with the partitions 88.

Movement of the armatures 96, to the right, is effected when the coil 94 is energized, and limited, by engagement of the brake 32 with the partition 88, to provide a slight air gap between each armature 96 and the corresponding core 92.

The clutch disc 30 is of substantially the same diameter as the brake 32, and has a friction facing ring or band 102 extending radially between its inner and outer edges sufficient to alternately engage the brake 32 and the driving disc 28.

The means 24 further comprises an elongated actuator member or element 104 carrying the eye 52, at one end, and having, at its other end, a short length constituting a nut 106 on the screw shaft 62. In this instance, the screw threads of the nut and the shaft have rounded troughs, in which bearing balls are disposed to provide anti friction drive of the nut 106 by the shaft 54.

The actuator element 104 is of tubular form longitudinally slidably mounted in a bushing 108 supported in the outer end of the switch housing 18. The switches 20 and 22, which are in circuit with the motor 44, have push buttons 110 and 112, respectively, which must be held in the inner or push positions thereof to maintain the switch contact members in open circuit condition, and which close the circuit when released.

The switches 20 and 22 are mounted on a bracket 114 secured to the housing 18, as by bolts 116. A switch operating member 118, secured to the bracket 114 as by rivets or screws 120, has operating arms 122 and 124 for the switches 20 and 22, respectively, and which arms slope divergently of each other from the bracket 114 along and toward the actuator element 104 to end portions or loops 126 on each arm for pushing the buttons 110 and 112.

Referring also to Figure 2, split sleeve or collars 128 and 130, clamped to the actuator element 104, as by bolts 132, are disposed around the element 104 in concentric relation to the axis of the element and of the screw shaft 62.

Each collar 128 and 130 has a fixed radial outer shoulder 134, and a removable radial outer shoulder in the form of a split lock ring 136 disposed in a radial outer groove of the collar. In this instance, a washer 138 is disposed around each collar to cover the split in the ring 136, and to thereby prevent any possible interference by the lock ring, by reason of its split, with rotative adjustment of switch arm operating members 140 and 142 disposed around the collars 128 and 130, respectively. The washer 138, which is of advantage in certain applications, may be omitted in other cases, as desired.

Each member 140 and 142 has an outer perimeter 144 eccentric to the axis of the corresponding collar, and including means, such as recesses 146, providing for adjusting the member about the element 104 and the corresponding collar,

as by the use of a spanner wrench or other tool.

Friction spring means 148, which in this instance is of annular wave-like form, surrounds each collar 128 and 130 and is compressed axially between the corresponding shoulder 134 and the corresponding member 140 and 142 for maintaining the latter in adjusted position.

To adjust the length of the strokes of the actuator element 104, the collars 128 and 130 are moved axially along the element to effect major steps of such adjustment, and set in adjusted position by manipulating the bolts 132.

To effect fine or micrometric steps of such adjustment of the stroke of the actuator element 104, each arm operating member 140 and 142 is moved about its axis against the action of the spring 148, which not only yields for such adjustment, but also sets the member 140 or 142 in adjusted position, without requiring the removal or release of any element.

Figure 2 indicates the member 140, by a dot-and-dash line and a full line, respectively, in different positions to which it may be adjusted.

The latter adjustment, by reason of the eccentricity of the perimeter 144, particularly as viewed in Figure 2, raises or lowers a point B on such perimeter, which engages the corresponding switch arm 122 or 124 to any position in distance A, thereby shortening or lengthening the axial distance which the eccentric member 140 or 142 must travel to actuate the corresponding switch 20 or 22. Thus, the member 140 is adjusted laterally of the axis of the element 104 to raise or lower the point B to effect the longitudinal or axial movement of the element 104.

Cup-like members 150 constituting stationary stops fitted in recesses in the housing portions 14 and 18, respectively, support belleville springs 152, which are held in position by lock rings 154 disposed in grooves in the member 150, for engagement with stop end portions 156 of the collars 128 and 130, respectively. These springs, which are of sheet metal, and of frusto-conical washer-like shape, have characteristics effective against high loads in short range of axial deflection, which does not vary appreciably over a substantial critical portion of such range. These characteristics render the springs exceptionally effective in the combination hereof for quick short range cushion stop action. The springs conserve space and weight by comparison to coil springs or other cushioning means, which would be ineffective in the places of the springs 152 hereof.

Although the springs 152 may be employed singly or of various numbers in series in each of the members 150, one is employed in each member 150, in this instance.

In operation, with the parts positioned as they are when the motor 44 and the coil 94 are deenergized, as illustrated, the left hand switch 20 is open, but the right hand switch 22 is closed to condition the circuit such that, when a main operating switch, not shown, is thrown, in one direction, to close the circuit of closed switch 22, the motor 44 actuates its shaft 82 to rotate in the proper direction for causing the screw shaft 62, to move the actuator element 104 to the right. The latter movement immediately causes the arm operating member 140 to release its arm 122 to close the switch 20, but the circuit of the latter switch is maintained open by reason of the fact that the main operating switch has been moved in the above-mentioned direction closing the circuit of the switch 22.

When the arm operating members 140 and 142 are thus both out of contact with and between the switches 20 and 22, at any desired position, the latter switches are both closed, such that, by opening the main switch to open the circuit of the switch 22, the actuator element 104 will be stopped in such position. Thereafter, the main switch may be again closed in the above-mentioned direction to close the circuit of the switch 22 and continue movement of the element 104 to the right, or the main switch may be closed in the opposite direction to close the circuit of the switch 20 and cause movement of the element 104 to the left.

Also, with the parts positioned as they are when the motor 44 and the coil 94 are deenergized, the springs 76 prevail over the spring 74 to engage the brake 32 to the clutch disc 30, whereby the pinion 66 and the mechanism at the output side of the pinion are prevented from being moved.

When the motor 44 and the coil 94 are next energized, the armatures 96 are at first attracted to the cores 92 against a force equal only to the difference between the force of the springs 76 and the spring 74, this reduced pull being at a time when the armatures 96 are farthest from the cores 92 and continuing until the clutch disc 30 engages the driving disc 28.

Upon this action, when the armatures 96 are closer to the cores 92 in a stronger flux field, the brake 32 is more readily pulled free from the clutch disc 30 against the full force of the springs 76. With the driven shaft 68 thus connected to the driving or motor shaft 82, the

motion is transmitted through the pinion 66, the gear train 16 and the gear 64 to the screw shaft 62 to cause the actuator element 104 to move axially, as aforesaid.

If the element 104 is allowed to travel its full working stroke to the right, the switch 22 is actuated by the arm operating member 142 to deenergize the motor 44 and the coil 94, whereupon the brake is substantially released and is moved by the springs 76 into contact with the clutch disc, applying a braking effect and simultaneously moving the clutch disc out of contact with the driving disc 28 against the force of the spring 74.

This action occurs also when the motor 44 and the coil 94 are deenergized by opening the main switch.

The springs 152 cushion the shock of stopping the actuator element 104, in case of excessive overtravel of the latter for any reason and, by preloading the screw shaft 62 and the nut 106, they prevent jamming between the screw and the nut, and render it easier to reverse rotation of the shaft.

Referring to Figure 3, in which corresponding parts are designated by corresponding reference numerals, the construction and operation are similar to those above set forth, with the exception that a pair of springs 158, of the same construction and characteristics as the springs 152 above set forth, is carried by each of collars 160 and 162 for cooperation with stationary stops 164 and 166, respectively.

Each collar 160 and 162 has a radial outer fixed shoulder 168 against which the springs 158 are held, as by lock rings 170, and although the springs may be employed singly, as shown in Figure 1, or of various numbers in series, two are employed in the structure of Figure 3, nested one within the other to increase the resistance of one spring in the given radial and axial space for the desired effect in this instance.

Although only one embodiment of the invention has been illustrated and described, it will be understood that various changes in the form and relative arrangements of the parts may be made to suit requirements within the scope of the invention.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. An actuator device comprising a linearly movable output element adapted to be driven by a motor or the like and having means carried thereby for actuating switch or other responsive means during movement of the element to limit its stroke, the actuating means including a member surrounding the element and having an outer peripheral portion eccentric to the axis of movement thereof, wherein the said member is angularly adjustable about the axis of said element for varying the movement of said element necessary to actuate the responsive means and wherein the member is held in its adjusted position by holding means associated therewith.

2. An actuator device as claimed in Claim 1, wherein the actuating means comprises a first member movable relatively to the element in its direction of movement to effect major steps of said adjustment, means for holding said first member in its adjusted position, a second member surrounding said first member and having an outer peripheral portion eccentric to the axis thereof and movable angularly about said axis to effect fine steps of said adjustment, and means for holding said second member in its adjusted position.

3. An actuator device as claimed in Claim 2, wherein the first member comprises a collar having fixed and removable radial outer shoulders spaced axially one from the other, and the second member surrounds said collar between said shoulders, friction spring means being located also around said collar between said second member and one of said shoulders, against the action of which spring means said adjustment is affected.

4. An actuator device as claimed in Claim 3, wherein the removable shoulder comprises a lock ring located in a peripheral outer groove formed in said collar, and the spring means is of annular wave-like form.

5. An actuator device as claimed in either of Claims 3 or 4, wherein the element is shaft-like and has means operatively associated therewith for longitudinally moving the said element, the said first member comprising an axially split collar adapted to be concentrically clamped to the element.

6. An actuator device as claimed in any preceding claim, wherein the motor operable to move the element is in circuit with switch means supported laterally of the path of movement of the element and engageable by the eccentric portion of the member carried thereby.

7. An actuator device as claimed in Claim 6, wherein the switch means is actuated through a switch operating arm sloping along and towards the element, which arm is adapted to be engaged by the actuating member and moved to actuate the switch means.

8. An actuator device as claimed in either of Claims 6 or 7, comprising a screw shaft, a brake, a motor having a shaft for operating the screw shaft, a clutch for alternately connecting the screw shaft to the motor shaft and the brake and electro-responsive means in circuit with the motor for simultaneous energization and deenergization therewith and adapted, when said circuit is energized, to actuate the clutch to disengage the screw shaft from the brake and connect the screw shaft to the motor shaft, and when the circuit is deenergized, to actuate the clutch to disconnect the screw shaft from the motor shaft and engage the screw shaft with the brake to stop rotation of the screw shaft, the movable element having a nut portion operated by the screw shaft for axially reciprocating said element.

9. An actuator device as claimed in Claim 8, having switch means adapted to control the opening of the motor circuit at the ends of the opposite working strokes of said element, the said element carrying a pair of actuating members each associated with a corresponding switch.

10. An actuator device as claimed in any preceding claim, wherein the movable element is formed with stop means co-operating with stationary stop means to limit the axial movement of said element.

11. An actuator device as claimed in Claim 10 as appendant to Claim 8 or 9, wherein said stationary stop means comprises a ring of substantially cup shape surrounding said screw shaft adjacent to said nut portion and a like ring surrounding said actuator element, the mouth ends of said cups facing each other and the sides of the cups having inner peripheral grooves, spring means in each of said cups of short range axial movement and high load characteristics for cushioning the impact between one of said movable stop means and one of the stationary stop means at the ends of the maximum strokes of said actuator element in each direction, and lock ring means in each of said grooves for holding the corresponding spring means in the corresponding cup.

12. An actuator device as described and shown in Figures 1 and 2 of the accompanying drawings.

13. An actuator device as described and shown in Figures 1 and 2 and as modified by Figure 3 of the accompanying drawings.

Dated this 10th day of June, 1947.
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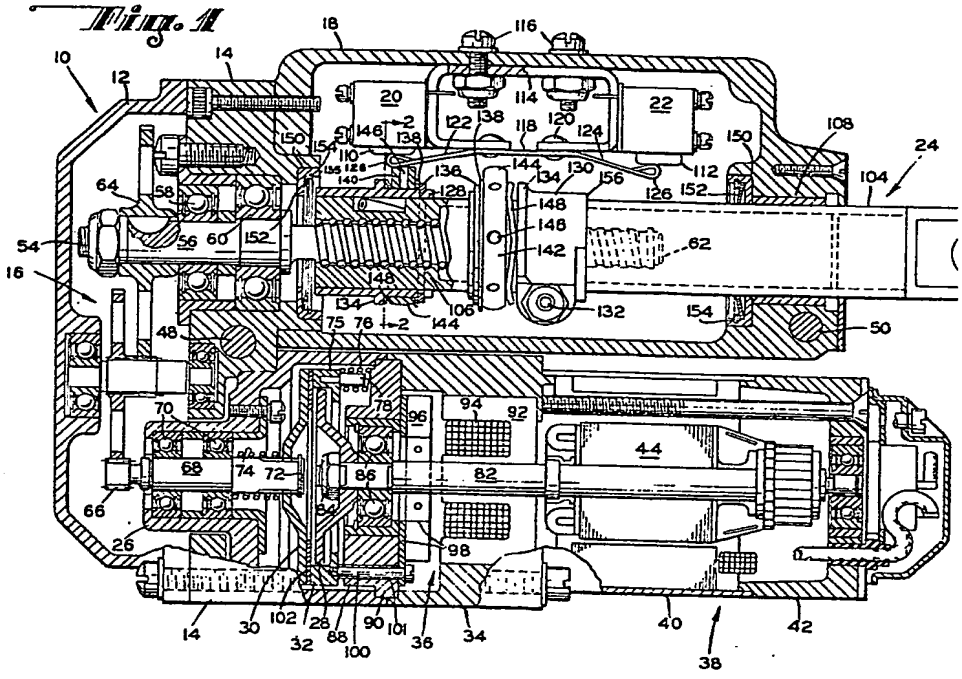
Fig. 1



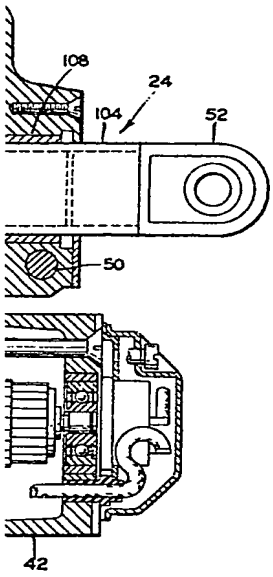


Fig. 3

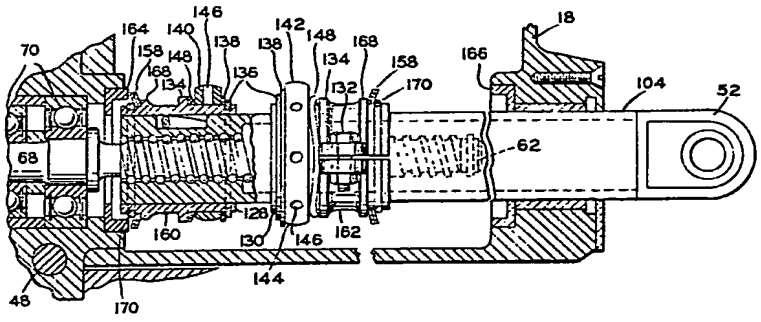
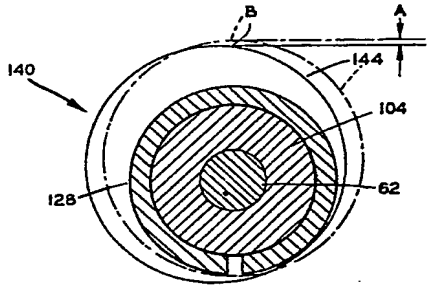


Fig. 2



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2 SHEETS

SHEET 1

SHEET 2

[This Drawing is a reproduction of the Original on a reduced scale]

Fig. 1

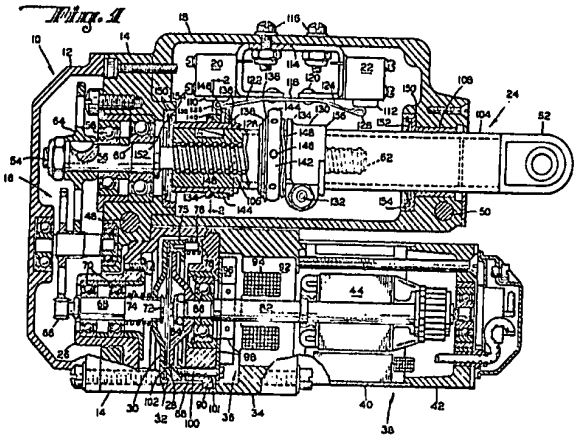


Fig. 3

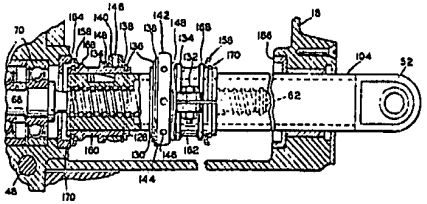
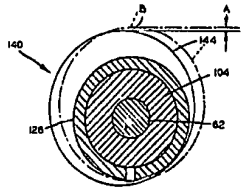


Fig. 2



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